
5.0 QUALITATIVE ASSESSMENT OF BENEFITS

The Phase II rule requires regulated municipalities to develop a storm water management program comprising six minimum measures that are expected to reduce the impact of storm water runoff on the nation's waters. The rule also requires owners of construction sites that disturb between one and five acres to implement erosion and sediment controls. This chapter qualitatively assesses the potential benefits of both the municipal measures and construction controls. Chapter 6 presents an analysis of those benefits quantified for this Economic Analysis.

A number of potential problems are associated with assessing the benefits resulting from the municipal program, including identifying the regulated municipalities as sources of current impairment to waters and determining the likely effectiveness of the various measures. Water quality modeling may assist in the identification and determination of the relative sources of impairment; however, past experience may be the only source of information on program effectiveness. The assessment presented here relies on existing literature for the evaluation of both the municipal program and construction runoff program effectiveness, as well as for the anticipated environmental impacts. The construction site controls discussion is further supplemented by EPA's model of the potential effectiveness of these controls and anticipated sediment loads during wet weather events.

5.1 Municipal Minimum Measures

Under the Phase II rule, municipalities with storm sewer systems serving populations of less than 100,000 located in Census-designed "urbanized areas" will be required to control storm water runoff through the implementation of six municipal minimum measures. EPA expects that these measures will reduce storm water flows and loadings of pollutants including BOD, oil and grease, metals (lead, copper, nickel, cadmium, zinc), phosphorus, nitrogen, some pathogens from illicit discharges, street debris, and construction sites. These reductions will lead, in turn, to improved water quality and habitat in receiving waters, resulting in a range of benefits.

5.1.1 Description of Measures

The six municipal minimum measures are described below. The anticipated benefits of these measures are discussed in Section 5.1.2.

Public Education and Outreach

The public education measure requires municipalities to inform citizens, organizations, and businesses about local water quality problems, how storm water runoff affects local water bodies, and how detrimental effects can be prevented. The benefits of a public education program could be measured by the number of households, organizations, or businesses that alter their behavior in an attempt to reduce the impacts of storm water runoff. EPA expects that public education will result in reduced pollutant loadings due to an increased awareness of the causes of water quality impairment. For example, a BMP education program in the Lake Tahoe watershed used a newsletter to educate residents about the cause and effect relationship between land use practices and water quality, and provided "how to" information on specific BMPs (Christopherson, 1995). The results of this program, documented through a telephone survey of

newsletter readers and nonreaders, showed that readers were better able to correctly identify the causes of declining water quality (37% versus 26%) and increased algae growth (65% versus 45%), and were more familiar with the term “BMPs” (38% versus 14%). Readers also accounted for 80% of the reported implementation of BMPs.

In another example, Montana State University conducted a voluntary private well water testing program involving instructional videos, written instructions, and well water sample collection and submission (Bauder, 1993). The impact of the program was assessed through a questionnaire that was mailed out 1 year after results of the water testing program were distributed to program participants. Forty-four percent of program participants returned the questionnaires with 65% indicating that they understood the test results that they had received the previous year; only 3.5% did not understand the test results. Seventy percent of respondents reported an improved ability to make decisions about water quality, and 84% rated the program as moderate to very effective at increasing public awareness of water quality issues. The average value placed on the program information and testing opportunity was \$108 per person, nearly nine times more than the cost of participation. By the end of the program, 12% had purchased point-of-use treatment equipment and 8% had made changes in land use practices. Twenty-five percent thought they should initiate a regular sampling and testing program compared to 15% of respondents that, prior to the program, had indicated occasional testing (once every five years or less) of their water supply.

The Tillamook Bay Rural Clean Water Project in Oregon also conducted a public education program to educate the local agricultural community about water quality issues (Ryan, 1989). The program involved one-on-one contact between Soil Conservation Service employees and farmers, visits and tours of successful BMPs, newsletters, brochures, and presentations. Public participation in local water quality problem solving was encouraged through workshops and the activity of the Citizen Advisory Committee. The program earned the participation of 98% of the farmers in the critical areas; 73% of whom implemented BMPs. Four years after the program began, there was a 40% to 60% improvement in bacteria conditions in the Bay and a 50% to 80% improvement in the rivers (Ryan, 1989).

Public Involvement and Participation

The public involvement and participation measure requires municipalities to involve members of a community in the development, implementation, and review of a municipality’s storm water management program; for example, acting as citizen representatives on a local storm water management panel, attending public hearings, working as citizen volunteers to educate other individuals about the program, or participating in volunteer monitoring efforts. EPA expects public participation to increase the awareness of water quality problems, increase the acceptance of storm water control programs by the local community through participation in the decision-making process, and improve water quality as a result of greater public involvement in storm water management. The benefits of public participation programs are difficult to measure because it is hard to value an increase in participation or an improvement of program design.

Illicit Discharge Detection and Elimination

The illicit discharge detection and elimination measure requires the owner or operator of a regulated small municipal separate storm sewer system to demonstrate awareness of the system;

to develop a storm sewer map showing the location of major pipes, outfalls, and topography; to effectively prohibit illicit discharges into the separate storm sewer system; to implement appropriate enforcement procedures; to develop and implement a plan to detect and address illicit discharges, including illegal dumping into the system; and to inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste, through programs such as storm drain stenciling. EPA expects that the identification of illicit discharges and their subsequent elimination will reduce the flows and pollutant loadings entering small streams and storm sewer systems.

For example, during a 12-month period, the Houston, Texas, Public Utilities Department identified 132 sources of discharges leading to Buffalo Bayou, the local drinking water source, with estimated flow rates ranging from 0.3 to 31.5 liters per second. Houston's program involved monthly sampling from bridge crossings; analysis of samples for carbonaceous biochemical oxygen demand, ammonia and nitrate nitrogen, pH, TSS, DO, temperature, fecal coliform, and chlorine residual; comparison of samples to baseline flow concentrations; weekly sampling of temperature, dissolved oxygen (DO), and fecal coliform in stream reaches suspected of contamination; boat sampling to identify the contaminating outfall along the reach; and, finally, a land-based search to pinpoint the source. Of the flows identified during the program, 85% were due to broken or clogged wastewater lines and 10% were due to illicit connections (Glanton et al., 1992). Eight months after an illicit discharge detection and elimination program began, fecal bacteria log mean concentration was reduced from 20,000 colonies/100 mL to 2,000 colonies/100 mL. In this example, the impacts of illicit discharge programs can be measured by reduced flows and pollutant loadings resulting from the elimination of discharges.

Construction Site Storm Water Runoff Control

Municipal separate storm sewer system operators are required to develop, implement, and enforce programs that will result in the reduction of pollutants, particularly sediment and site-generated wastes, in storm water runoff from construction activities. Program requirements include preconstruction review of site management plans, regular inspections during construction, and provisions for receipt and consideration of information provided by the public. Construction site operators will implement on-site controls that include BMPs, such as silt fences or detention basins. EPA expects that implementing such programs will result in reduced pollutant loadings and flows entering small streams, with benefits including improved water and habitat quality. These impacts, which EPA has modeled (see Section 5.2.1), can be measured through performance measures for construction site controls (i.e., BMP effectiveness).

Post-Construction Storm Water Management in New Development and Redevelopment

The new development and redevelopment measure requires that land developers attempt to maintain predevelopment runoff conditions through controls that prevent or minimize water quality impacts from runoff and through adequate long term operation and maintenance of BMPs. Examples of these controls include minimization of site disturbance and vegetative cover preservation, minimization of impervious areas, maintenance or restoration of natural infiltration, wetland protection, and use of vegetated drainageways or riparian buffers. EPA expects that such foresight during development will result in the prevention of sediment and flow runoff. The impacts can be measured through the loadings reductions based on performance estimates for the implemented controls.

Pollution Prevention/Good Housekeeping for Municipal Operations

The good housekeeping measure requires that storm sewer systems and storm water pollution control structures are properly operated and maintained with the goal of preventing or reducing pollutant runoff from municipal operations. Examples include long term inspection procedures for structural storm water controls to reduce the discharge of floatables and other pollutants from the separate storm sewers and controls in an attempt to reduce or eliminate the discharges of pollutants from streets and other municipally controlled paved areas. An example of a pollution prevention procedure is training municipal employees regarding the reduced application of pesticides on municipally-owned golf courses or parks. EPA expects that activities such as street or storm drain cleaning will reduce the pollutant loads carried in storm water flows, with benefits measured as the loadings reductions.

These cleaning techniques, however, vary in effectiveness depending on the size of particles removed. The inability to remove small particles means that techniques are less effective at reducing the loading of pollutants that tend to adhere to very small particles. For example, the city of Bellevue, Washington, found that street cleaning three times per week removed about only 10% of urban runoff pollutants; catch basin cleaning twice a year was estimated to be about 25% effective (Pitt and Bissonnette, 1984). Thus, the benefits of good housekeeping measures may be predominantly those associated with reduced floatables, such as enhanced recreation resulting from improved aesthetics (e.g., swimming, beach use, and hiking along the water).

5.1.2 Anticipated Benefits from the Municipal Minimum Measures

The Phase II rule is intended to reduce the harmful pollutant loadings and flows carried in storm water runoff. These reductions will affect the quantity and quality of storm water runoff, improve water quality, and result in a variety of benefits to users of affected waters. The types of benefits associated with the individual measures depend on the specific pollutants that are reduced.

Enhanced Commercial Fisheries

Pollutants in storm water (e.g., bacteria, solids, toxics) can adversely affect fisheries by reducing the possibilities of reproduction and survival, leading to lower yields, contamination and closure, or the elimination of a species. Approximately 27% of the square miles of estuaries surveyed for shellfishing use violated shellfishing harvesting criteria (US EPA, 1998a). Of the estuaries surveyed, 18% identified storm water as a source of impairment (US EPA, 1998a). The reduction of pollutants and the resulting improvement in water quality from public education, public participation, and illicit discharge detection and elimination may contribute to the recovery of these fisheries. Good housekeeping and street sweeping may also contribute to these benefits, although to a lesser extent due to the lower effectiveness of reducing pollutants that adhere to small particles, such as metals.

Enhanced Opportunities for Recreational Fishing

Pollutants in storm water runoff may result in decreased numbers or size of sport fish or shellfish species, or eliminate specific species from receiving waters. Fish or shellfish caught in impaired

waters also may be unsafe to eat. As of September, 1996, there were 2196 fish consumption advisories in 47 states, the District of Columbia, and American Samoa—65% of these advisories restrict the consumption of fish caught in lakes (US EPA, 1998). Approximately 24% of estuaries, 17% of rivers and streams, 35% of lakes, ponds, and reservoirs, and 98% of Great Lakes shoreline are not/partially supporting or in nonattainment for fish consumption use (US EPA, 1998a). The public education, public participation, and illicit discharge detection and elimination measures are expected to result in reduced pollutant loadings and improved water quality that may increase the number, size, and quality of fish in receiving waters, thereby opening up new areas to fishing, enhancing the experience for existing users, and possibly increasing activity associated with recreational fishing (e.g., nonconsumptive wildlife users often accompany individuals engaged in recreational fishing). Good housekeeping and street sweeping, by improving aesthetics associated with recreational fishing sites, may also contribute to enhanced opportunities for recreational fishing and related activities.

Enhanced Opportunities for Subsistence Fishing

Pollutants in storm water runoff may decrease the numbers or size of edible fish species or eliminate specific species from receiving waters. Fish caught in impaired waters also may be unsafe to eat, or may have low recommended limits for consumption. Through water quality improvements, the number, size, and quality of fish may improve, thereby opening up new areas to fishing, enhancing the experience for existing users, and increasing the safe consumption limits.

Enhanced Opportunities for Hunting

Pollutants in storm water runoff may decrease the habitat quality for waterfowl species, resulting in reduced numbers, reduced breeding, or the elimination of specific species from receiving waters. Additionally, birds feeding from impaired water bodies also may be unsafe to eat. Through water quality improvements, the number and quality of waterfowl may improve, thereby opening up new areas to hunting and enhancing the experience for existing users.

Enhanced Opportunities for Boating

Although boating does not necessitate human contact with water, boaters are sensitive to water quality. High turbidity, eutrophication, odors, floating trash, and other visible contamination can discourage boaters from using a waterway. However, storm water controls may offer benefits to boaters by reducing contamination entering impaired waters and increasing water clarity, thereby opening up new areas to boating and enhancing the experience for existing users.

Enhanced Opportunities for Swimming

Because swimming necessitates direct contact with water, swimmers may have concerns about water contamination and its relation to aesthetic preferences and potential health risks. Turbidity, algae blooms, odors, floating trash, and other visible contamination, as well as posted health hazard warnings, can discourage swimmers from using a water body. In 1993, 180 million Americans visited ocean and bay beaches (Weber, 1995). The Natural Resources Defense Council (NRDC, 1997) reported 2,596 beach closures (1,054 of which were in California) or advisory days due to sources such as overflowing sewers and storm drains (each

day that a beach was closed was counted as a separate day). In addition, it should be noted that many coastal states do not monitor beaches or monitor only portions of their coastline (NRDC, 1997), so many more beach closings and advisory days may have been necessary.

Additionally, local health departments restricted recreation at 342 individual sites at least once during 1995 and 1996. Storm water controls may offer benefits to swimmers by making waters suitable for swimming where currently it is not desirable or safe.

Enhanced Opportunities for Noncontact Recreation

Activities such as picnicking, jogging, biking, photography, and camping do not necessitate direct contact with water; however, water quality affects the ability to enjoy these activities when in close proximity to water. High turbidity, eutrophication, odors, floating trash, and other visible contamination can discourage recreational activity near a water body. However, storm water controls may offer benefits by reducing contamination and allowing impaired waters to be used as focal points for recreational activities where they are not currently in demand for such use. These improvements also may enhance the experiences for current users.

Enhanced Nonconsumptive Wildlife Uses

Wildlife viewing activities can be affected by impaired water quality through the reduced quantity and variety of species living in or near water bodies. An estimated 76.1 million people participated in nonconsumptive wildlife use in 1991, with 54.7 million observing wildlife and 19.1 million observing waterfowl and shorebirds (US EPA, 1994). Storm water controls that result in greater numbers or diversity of viewable wildlife species will produce benefits measurable by increased trips and greater amounts of wildlife seen per trip.

Reduced Flood Damage

Storm water runoff controls may mitigate flood damages by providing additional storage capacity, diversion of runoff, and reduced sedimentation from flood waters. The benefits from reduced flows and sedimentation can be measured by the reduced damage from flood flows and the reduced amounts of sediment deposited by flood waters requiring cleanup.

Drinking Water Benefits

Storm water was identified as a major source of impairment in 3% of surveyed rivers and streams and 6% of surveyed lakes, reservoirs, and ponds (US EPA, 1998a). Numerous municipal, industrial, and agricultural users treat the surface waters of streams, rivers, and lakes prior to their use for drinking water, manufacturing, or power generation. Pollutants from storm water runoff, such as solids, toxics (including pesticides), and bacteria, may impose additional costs for treatment or even render the water unusable, thereby forcing the use of an alternative source. Standards for drinking water, manufacturing, and power generation vary considerably, but reducing runoff may result in avoided treatment and savings for municipalities, commercial facilities, and farmers.

Polluted water also can cause damage to household pipes and appliances. Lowering contaminant levels can reduce this damage. Benefits for drinking water can be measured by the avoided additional treatment to compensate for contributions of storm water runoff to water sources, but also may be considered benefits under the federal drinking water program.

Water Storage Benefits

Storm water was identified as a major source of impairment in 6% of impaired lakes, ponds, and reservoirs surveyed (US EPA, 1998a). The heavy load of solids deposited by storm water runoff can lead to rapid sedimentation of reservoirs and other receiving water bodies, meaning a loss of needed water storage capacity, which must either be replaced (if possible) or the existing reservoirs must be dredged. The benefits of storm water controls, in particular the construction site runoff measure, can be measured by reduced storage replacement or reservoir dredging and reduced costs of cleaning out storm sewers.

Navigational Benefits

Storm water sediment loads also are delivered to and deposited in harbors and rivers critical to navigation and commerce. Where the waters are used for navigation, solids must be dredged and disposed of to maintain the utility of the waterway. In 1995, 251 million cubic yards of material were dredged from navigational waterways (US ACE, 1996). An estimated 5% of this can be attributed to roads and construction sites, representing 12.6 million cubic yards of material (Clark et al., 1985). Benefits of storm water runoff controls can be measured by avoided dredging and disposal costs.

Reduced Illness from Consuming Contaminated Seafood

Storm water controls may reduce the presence of pathogens in seafood caught by commercial or recreational anglers. Bean et al. (1996) identified 679 cases of shellfish-vector disease between 1988 and 1992. Rippey (1994) estimated that illnesses were under reported by a factor of 20 or more, leading to an annual estimate of 2,700 cases of illness each year. Benefits from decreased levels of pathogens may include lower incidences of illnesses due to raw or partially cooked seafood.

Reduced Illness from Swimming in Contaminated Waters

Swimmers may accrue similar benefits, especially when storm water runoff contains high levels of bacteria or parasites. Epidemiological studies demonstrate that swimmers who immerse their heads in waters with high densities of bacterial indicators bear a greater risk of contracting gastrointestinal or respiratory illnesses than those who do not immerse their heads (Haile et al., 1996). Benefits of decreased pathogen levels may include a reduction of such bacteria-related illnesses.

Enhanced Aesthetic Value

When storm water affects the appearance or quality of a water body, the desirability of working, living, traveling, or owning property near that water body is similarly affected. A reduction in storm water pollution and excessive flows resulting in the improved quality of a water body,

such as more diverse or plentiful vegetation or wildlife, or overall better water quality, will result in benefits as these waters recover and become more desirable locations near which people want to live, work, travel, or own property.

Other Ecosystem Improvements

Increased peak flows resulting from urbanization (e.g., from increased impervious surfaces) can cause catastrophic damage in receiving streams and stream valleys, including streambank or streambed erosion, vegetation damage, inundation and flooding, and sediment deposition. Forested areas, wetlands, estuaries, and shorelines can become submerged under water or sediment can be deposited by storm flows. Impacts include loss of land, ecosystem and habitat damage, and high downstream sediment loads. Benefits from reduced flows can be measured by the reduced need for streambank, streambed, vegetation, or near stream and shore maintenance. Other benefits can be measured by the reduced need to remove sediment from downstream reaches or to repair ecosystem or property damage resulting from high sediment loads.

5.2 Construction Site Controls

The Phase II rule requires that construction sites between one and five acres in size control storm water to prevent the runoff of sediment and pollutants into nearby water bodies. Typical methods of controlling runoff include BMPs such as the minimization of site disturbance or vegetation removal and silt fencing. EPA expects the implementation of such programs to result in reduced pollutant loadings and flows entering small streams with subsequent benefits in the form of improved water quality and habitat of receiving waters.

5.2.1 Model of Construction Site BMP Effectiveness

To estimate the effectiveness of the erosion and sediment control practices for which costs were estimated in Chapter 4 for the 27 model construction sites, EPA and the US ACE modeled the effectiveness of the practices in reducing soil loss from those model sites using the Revised Universal Soil Loss Equation (RUSLE) (US ACE, 1998). Although RUSLE is limited to the development of average annual sediment loss, the model provides insight into how construction practices can impact soil loss from a site and how these impacts can vary regionally across the United States. Specifically, disturbances to the soil can result in sediment loss increases ranging from 140% to 2,210% depending on the climatic region. The results show varying effectiveness of BMPs and may be useful for site planning. For example, silt fencing alone may not be sufficient for sandy soils. Alternatively, some combinations of BMPs may overcompensate and thus fewer controls may be needed.

Offsite transport of soil lost during construction was modeled for one location using Agricultural Nonpoint Source Pollution Model (AGNPS), an empirically based, single event watershed runoff, erosion, and pollution transport model (US ACE, 1998). Although the RUSLE model is considered more credible for calculating soil loss, the AGNPS model provides insight into how material is transported within a watershed. The model was used to determine sediment movement through three generalized watershed sizes under varying degrees of construction. The results showed that soil type, watershed size, and construction site location with respect to the

outlet of a watershed are important determinants in the transport of soil through a channel to a downstream portion of the watershed.

For all watershed, slope, and construction densities tested, approximately half of the eroded soil from upland portions of a watershed with silt or clay soil was yielded to a downstream portion of the watershed (US ACE, 1998). However, for sandy watersheds, only a small portion of eroded soil was deposited downstream. Upland construction sites had far less impact than those located near watershed outlets. And, the model showed that construction in smaller watersheds results in a larger percentage increase in sediment yield from the watershed—up to a 70% increase in yield for 30 acres of construction in a 99-acre watershed compared to a 12% increase in yield for 30 acres of construction in a 639-acre watershed.

5.2.2 Anticipated Benefits of Construction Site Controls

Implementation of construction site BMPs is expected to improve the water quality and physical condition of both small streams and larger water bodies. Runoff from construction sites may be particularly damaging to *small streams* because of the streams' typically small flow volume and channel size, thus lessening the ability to accommodate high flows and large sediment loads.

Siltation has been identified as the leading pollutant or process affecting rivers and streams in the nation (US EPA, 1998a). Although agriculture produces the largest sediment load, construction results in the most concentrated form of erosion and the rate of erosion from construction sites may exceed that of agricultural land by ten to twenty times (Water Environment Federation, 1992).

During storms, construction sites may be the source of sediment-laden runoff, which can overwhelm a small stream channel's capacity, resulting in streambed scour, streambank erosion, stream "blow out," and destruction of near-stream vegetative cover. As the flow velocity decreases, sediment from construction site runoff settles out, blanketing the streambed, burying macroinvertebrates, and eliminating the natural stream substrate. Streams that are overwhelmed by runoff can become wider and, consequently, exhibit shallower base flow, lose the natural riffle-run morphology, lose to erosion vegetative cover that shades the stream and mitigates temperature swings, and lose their habitat value for aquatic species. The recurrence of high storm water flows maintains these degraded conditions, ultimately resulting in water quality and habitat degradation. The prevention of sediment and flow runoff from construction sites will mitigate this degradation.

Although small streams are frequently the first water body with which storm water comes into contact, these streams subsequently drain into *larger streams, rivers, ponds, lakes, wetlands, bays, estuaries, or oceans*. Thus, stream reaches affected by construction activities often extend well downstream of the construction site. For example, between 3.0 and 3.5 miles of stream below construction sites in the Patuxent River watershed were observed to be impaired by sediment inputs (Klein, 1979). It is near these downstream water bodies that a large share of the population lives or participates in water-dependent recreation. When small stream habitat and water quality degrades, the downstream systems also are affected, suffering poorer water quality and less upstream habitat for aquatic-dependent species. When small stream habitat and water quality improves, downstream water bodies also will realize water quality and habitat

improvements, resulting in benefits for the population living nearby or using the resource for recreation, as described below.

Enhanced Commercial Fisheries

Sedimentation can adversely affect fisheries by reducing the possibilities for reproduction and survival of fish, leading to lower yields or the elimination of a species. Excessive sediment loads can bury fish eggs and stream substrates favorable for fish reproduction. Additionally, excessive flows may wash eggs downstream.

Enhanced Opportunities for Recreational Fishing

Construction site runoff may increase turbidity in receiving waters and blanket streambeds with sediments, covering eggs or favorable substrates for egg laying. This, in turn, leads to adult mortality from impaired feeding or respiration, decreased reproductive success resulting in decreased numbers or size of sport fish, or the elimination of a specific species from receiving waters. Through water quality improvements, the number, size, and quality of fish may improve, thereby opening up new areas to recreational fishing and enhancing the experience for existing users.

Enhanced Opportunities for Subsistence Fishing

Construction site runoff may increase turbidity in receiving waters and blanket streambeds with sediments, covering eggs or favorable substrates for egg laying. This, in turn, leads to adult mortality from impaired feeding or respiration, decreased reproductive success resulting in decreased numbers or size of edible fish, or the elimination of a specific species from receiving waters. Through water quality improvements, the number, size, and quality of fish may improve, thereby opening up new areas to fishing and enhancing the experience for existing users.

Enhanced Opportunities for Hunting

Construction site runoff may decrease the habitat quality for waterfowl species through the burying of food sources, inundation of habitat, or damage to nesting areas, resulting in reduced numbers, reduced breeding, or the elimination of a specific species using receiving waters. Through water quality improvements, the number and quality of waterfowl may improve, thereby opening up new areas to hunting and enhancing the experience for existing users.

Enhanced Opportunities for Boating

Although boating does not necessitate human contact with the water, boaters are sensitive to water quality. Sediment runoff from construction sites results in turbidity, which may discourage boaters from using a waterway. However, storm water controls may offer benefits by reducing sediment loads entering impaired waters and increasing water clarity, thereby opening up new areas to boating and enhancing the experience for existing users.

Enhanced Opportunities for Swimming

Turbidity in surface waters may reduce the safety of waters for swimming. For example, swimmers may be unable to judge the depth of cloudy waters or to see vegetation that may interfere with swimming. Storm water controls offer benefits to swimmers by making waters suitable for swimming where it currently is not desirable or safe.

Enhanced Opportunities for Noncontact Recreation

Activities such as picnicking, jogging, biking, photography, and camping do not necessitate contact with the water; however, water quality affects the ability to enjoy these activities in close proximity to water bodies. High turbidity may discourage recreational activity adjacent to water bodies. However, storm water controls may offer benefits by encouraging impaired waters to be used as focal points for recreational activities where they are not currently in demand for such use and by enhancing the experiences for current users.

Enhanced Nonconsumptive Wildlife Uses

Wildlife viewing activities are affected by impaired water quality through the reduced quantity and variety of species living in or near water bodies. Construction site storm water controls that result in lower turbidity and sedimentation will make food and breeding habitats more accessible; thus, greater numbers or diversity of viewable wildlife species will be available. Benefits are measurable by increased trips and greater amounts of wildlife seen per trip.

Reduced Flood Damage

Storm water runoff controls may mitigate flood damages by providing additional storage capacity, diversion of runoff, and reduced sedimentation from flood waters. The benefits from reduced flows and sedimentation can be measured by the reduced damage from flood flows and the reduced amounts of sediment deposited by flood waters requiring cleanup.

Water Storage Benefits

The heavy load of solids deposited by storm water runoff can lead to rapid sedimentation of reservoirs and other receiving water bodies, meaning a loss of needed water storage capacity, which must either be replaced, if this option exists, or the existing reservoirs must be dredged. The benefits of storm water controls can be measured by reduced storage replacement, or reservoir dredging and reduced costs of cleaning out storm sewers.

Navigational Benefits

Storm water sediment loads also are delivered to and deposited in harbors and rivers critical to navigation and commerce. Where the waters are used for navigation, solids must be dredged and disposed of to maintain the utility of the waterway. In 1995, 251-million cubic yards of material were dredged from navigational waterways (US ACE, 1996). An estimated 5% of this can be attributed to roads and construction sites, representing 12.6-million cubic yards of material (Clark et al., 1985). Benefits of construction site runoff controls can be measured by avoided dredging and disposal costs.

Enhanced Aesthetic Value

When storm water affects the appearance or quality of water bodies, the desirability of working, living, traveling, or owning property near that water body is similarly affected. A reduction in storm water sediment loads and excessive flows resulting in the improved quality of a water body, such as increased water clarity or more diverse or plentiful vegetation or wildlife, will result in benefits when impaired waters recover and become more desirable locations near which people want to live, work, travel, or own property.

Other Ecosystem Improvements

Increased peak flows resulting from urbanization (e.g., from increased impervious surfaces) can cause catastrophic damage in receiving streams and stream valleys such as streambank or streambed erosion, vegetation damage, inundation and flooding, and sediment deposition. Forested areas, wetlands, estuaries, and shorelines can become submerged or sediment can be deposited by storm flows. Impacts include loss of land, ecosystem and habitat damage, and high downstream sediment loads. Benefits from reduced flows can be measured by the reduced need for streambank, streambed, vegetation, or near stream and shore maintenance. Other benefits can be measured by the reduced need to remove sediment from downstream reaches or to repair ecosystem or property damage resulting from high sediment loads.

5.3 Conclusions

This chapter described the six municipal minimum measures that comprise the municipal storm water program as well as the construction site runoff program. Both programs are expected to control the impacts of storm water runoff and result in benefits to the nation's waters. Benefits include improved recreation, such as fishing, swimming, or boating; reduced flood damages; reduced drinking water and water storage requirements; reduced illness and health risks; enhanced aesthetic value; and finally, improved ecosystem health. Chapter 6 contains the discussion of the quantification and valuation of benefits.